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To: Docket Office, California Energy Commission (CEC)

From: C.K. Woo, E3

Re: 2007 IEPR – Scenario Analysis, Docket No. 06-IEP-1M

Question 11

The Energy Commission Staff reported work on a separate portfolio assessment project that seemingly guides how risks can be evaluated to identify a preferred resource mix.

(1) Can the results of the Scenario Project be packaged into the framework of portfolio analyses?

(2) If insufficient assessments have been completed in the results reported in the June 2007 report, what supplemental analyses would need to be prepared to allow a portfolio method to be applied in future IEPR cycles?

Response

As explained below, the answer for the first question is "conceptually yes, but empirically challenging"; this is notwithstanding that a scenario analysis can be a starting point for a portfolio analysis.

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A. Scenario vs. portfolio analysis

To address the first question, we explore the relationship between a scenario analysis and a portfolio analysis. Treating the existing resource mix as given, we define a scenario *S* using the following variables:

(1) **Policy parameters**. Some examples are: (a) the renewable portfolio standard (RPS) of 33% of a load-serving-entity's (LSE) retail sales; and (b) the resource adequacy requirement (RAR) of 15%-17% of a LSE's peak demand forecast; and (c) the greenhouse gas (GHG) emissions cap, which may be load- or source-based, imposed on a LSE.[1] These parameters are uncertain, with different probabilities of realization. While (a) and (b) are reasonably understood, (c) is presently evolving.

(2) **Random factors**. A limited list of the major factors includes: (a) weather (hot, normal, cool) that drives a LSE's MW demand and MWH sales; (b) hydro availability that drives wholesale electricity prices and a LSE's residual net short position; (c) large generation units' availability (e.g., Diablo and SONGS); (d) natural gas price that drives the wholesale electricity prices and a LSE's fuel costs; (e) out-of-state coal-based supply availability and price, which depend on the emerging emissions regulations; and (f) renewable energy supply availability and price that depend on out-of-state RPS and transmission availability.[2] These variables are uncertain, with

[1] Orans, R., S. Price, J. Williams, C.K. Woo and J. Moore (2007) "A Northern California - British Columbia Partnership for Renewable Energy" Energy Policy, 35:8, 3979-3983; Tishler, A., I. Milstein and C.K. Woo (2007) "Capacity Commitment and Price Volatility in a Competitive Electricity Market," Energy Economics, forthcoming.

[2] Woo, C.K., I. Horowitz, N. Toyama, A. Olson, A. Lai, and R. Wan (2007) "Fundamental Drivers of Electricity Prices in the Pacific Northwest," Advances in Quantitative Analysis of Finance and Accounting,

different probabilities of realization. While past experience may guide one's judgment of (a) – (c), international demands (e.g., China and India) for oil and natural gas can impact the domestic natural price in (d) in ways that differ from the past. Similarly, not much is known about (e) and (f).

Even though it may be impossible to precisely assign the probability of the variable values that define a given scenario, we can make a set of J plausible scenarios, $\{S_1, \ldots., S_J\}$. We can also construct a set of K admissible resource mixes, $\{R_1, \ldots., R_K\}$. A resource mix is said to be admissible if it meets the policy constraints (e.g., RPS and RAR) and is technically feasible (e.g., load-resource balance and no transmission constraint violation).

Now, we compute the present value cost of resource mix k in scenario j, resulting in cost C_{jk}. Repeating the cost computation for all scenarios yields the cost series $\{C_{1k}, \ldots, C_{Jk}\}$ for resource mix k. This cost series shows the cost performance of resource mix k across J scenarios.

To link a scenario analysis to a portfolio analysis, we compute the cost series for all resource mixes. The result is a set of cost series: $\{C_{11}, \ldots, C_{J1}\}$ for resource mix 1; $\{C_{12}, \ldots, C_{J2}\}$ for resource mix 2; … ; $\{C_{1K}, \ldots, C_{JK}\}$ for resource mix K.

With this data set, moving from a scenario analysis to a portfolio analysis is conceptually straightforward. To see this point, assume that one can assign the

forthcoming; Woo, C.K., A. Olson and I. Horowitz (2006) "Market Efficiency, Cross Hedging and Price Forecasts: California's Natural-Gas Markets," Energy, 31, 1290-1304.

probability of realizing scenario j as $\pi_j = \text{Prob}(S = S_j)$ for j = 1, …, J. The cost expectation of resource mix k is the probability-weighted average of the mix's cost series:

$$\mu_k \quad = \quad \Sigma_j \pi_j C_{jk}. \qquad (1)$$

The cost variance of resource mix k is:

$$\sigma_k^2 \quad = \quad \Sigma_j \pi_j (C_{jk} - \mu_k)^2. \qquad (2)$$

Repeating the cost expectation and variance computation for all resource mixes yields the cost expectation and variance combinations by resource mix: $\{(\mu_1, \sigma_1^2), \ldots, (\mu_K, \sigma_K^2)\}$, which is the input data for developing an efficient frontier in a portfolio analysis.[3]

To derive an efficient frontier, we select a resource mix p with minimum cost variance σ_p^2 ($\leq \sigma_{k'}^2$), among the resources mixes (indexed by k') that obey a cost expectation constraint: $\mu_{k'} \leq \mu$. As the cost expectation constraint is binding, the optimal resource mix p has a portfolio cost expectation and variance equal to ($\mu = \mu_p$, $\sigma^2 = \sigma_p^2$), a point on the efficient frontier. By varying the cost expectation constraint, we solve for the other points on the frontier.

B. Answer

Can the results of the Scenario Project be packaged into the framework of portfolio analyses? The answer is "conceptually yes, but empirically challenging".

It is "conceptually yes", as demonstrated above. It is "empirically challenging" because the existing scenario analysis may not have a sufficient number of scenarios that

[3] Woo, C.K., I. Horowitz, A. Olson, B. Horii and C. Baskette (2006) "Efficient Frontiers for Electricity Procurement by an LDC with Multiple Purchase Options," OMEGA, 34:1, 70-80; Woo, C.K., I. Horowitz, B. Horii and R. Karimov (2004) "The Efficient Frontier for Spot and Forward Purchases: An Application to Electricity," Journal of the Operational Research Society, 55, 1130-1136.

cover a wide range of possible outcomes. A few scenarios may mask the effect that a low probability scenario may have on a resource mix's cost expectation and variance. Even if the number of scenarios is sufficiently large, there is the challenge of assigning scenario-specific probabilities. To be fair, the challenge may be partly overcome via simulation that allows for possible correlations among key variables (e.g., hydro condition and natural gas). Nonetheless, there is still the difficulty of making reasonable assumptions of these variables' distributions.

The implications of this answer are as follows. First, the scenario analysis and the portfolio analysis should be a coordinated research since the former is the input for the latter. Second, the two analyses are complementary, and the scenario analysis should not be replaced by the portfolio analysis. Finally, there needs to be a good understanding of the variables that define a scenario, especially each variable's distribution and correlation with other variables.